"This is the Information Age.... Parks are created to a higher standard; the National Park Service should be held to a higher standard. The Park Service must take whatever steps are required to secure the information needed to make sound management decisions."

Dr. Robin Winks, environmental scholar and former chair, National Park System Advisory Board

Scientific Information for Management

NPS PHOTO

A mountain lion at Grand Canyon National Park triggers an infrared camera used in the noninvasive study of the large carnivore species. Self-portraits like this can often be correlated with specific tracks, hair, or feces left behind at sampling stations, adding another dimension to the study of lion kinship, food sources, and home range.

The National Park Service needs the best information science can offer to manage the national parks. In recent years—partly as a result of the National Parks Omnibus Management Act of 1998, a broadening commitment to meet this need among park managers, and increased funding from the Natural Resource Challenge—parks have made substantial progress in this area. Many small parks have hired their first natural resource manager, and increased expertise is resulting in better identification of information needs and a greater capacity to interpret and apply scientific information. Baseline inventories continue to deliver important fundamental information for management, and monitoring networks are now organizing to track long-term trends in park natural resources. Parks, too, are becoming friendlier places for researchers to do their work thanks to the developing network of research and learning centers and the streamlining of research permitting. Collaboration through partnerships and the Cooperative Ecosystem Studies Units remains critically important to scientific endeavors in parks, providing expertise, cost-sharing, and creative problem solving. The following articles give us a glimpse into this world of scientific information in 2002 that is as fascinating as it is fundamental to park management.

DNA sampling key to noninvasive study of mountain lions in southwestern parks

by Elaine F. Leslie

MOUNTAIN LION SIGHTINGS AND ATTACKS ARE commonly reported throughout the National Park System. Knowing how and when these large carnivores use park habitat, especially areas frequented by humans, is key to reducing potentially dangerous interactions with humans and facilitates this species' protection.

"The animals' DNA fingerprint and food sources can … be determined without direct human contact."

A multiyear study is providing a framework for national parks in the Southwest to obtain information about mountain lions with minimal disruption to their natural behavior. Resource managers from Grand Canyon, Mesa Verde, Saguaro, Guadalupe Mountains, Carlsbad Caverns, and Zion National Parks and several national monuments near Flagstaff joined forces in 2002 in a multipark effort to collect DNA samples from mountain lions. Analyzed in the laboratory, the DNA identifies individuals and allows scientists to determine kinship and estimate population sizes. Before 2001 these parks had information on the presence of mountain lions, but little was known about how they used park habitat.

The parks are conducting DNA and food source studies of the reclusive species through the noninvasive collection of hair, skin, and feces. Trained staff and volunteers attach to trees small pads of carpet studded with nails and laced with scent. Attracted to these lures, mountain lions rub on the pad, leaving behind hair samples, or deposit feces, which often contain skin cells. Technicians collect the samples every two weeks and send them out for analysis. The animals' DNA fingerprint and food sources can thus be determined without direct human contact. Additional information comes from specialized cameras at some locations that catch mountain lions in the act of depositing their DNA. Investigators are therefore able to match the resulting photographs to mountain lion tracks and the DNA signatures, establish kinship, and map home ranges of the animals. The work is funded by the National Park Foundation, the Grand Canyon National Park Foundation, and the Colorado Plateau Cooperative Ecosystem Studies Unit.

Data collected since 2000 in Grand Canyon suggest that 7 adult mountain lions incorporate areas of high human activity, including the South and North Rim developed areas, into their home ranges. Another 19 mountain lions disperse or move through these areas seeking to establish home range. The majority of adult mountain lions using Guadalupe Mountains National Park disperse to nearby Carlsbad Caverns, according to early data analysis. At Mesa Verde, half of the 12 individuals identified in the first year of the study use the park as home range. (Data collection dropped off significantly following two years of intense fires and resulting habitat loss.) The Flagstaff area units of Walnut Canyon, Sunset Crater, and Wupatki National Monuments have identified one mountain lion from DNA samples.

This information has already led to changes at Grand Canyon. The park is developing a management plan that addresses visitor safety and mountain lion protection, outlining, for example, when area closures are warranted and standard procedures to follow in the event of an attack. To increase safety, park staff closely monitor or move the carcasses of animals killed by mountain lions and cached near campsites, residential areas, and trails. The park has also thinned vegetation along a path leading to a school in the park to make the area less appealing to mountain lions, and has stepped up its information campaign for visitors and residents alike.

This multipark study has added to knowledge of a large carnivore and demonstrated an effective model for increasing communication and collaboration among parks. Results will be compiled and loaded onto each park's Geographic Information Systems database. A brochure on mountain lion ecology and human safety has also been developed and is being distributed in the parks. Finally, in addition to developing management plans and standard operating procedures, the parks are planning for long-term monitoring of mountain lions beyond 2003 when the study ends. Grand Canyon National Park is also planning to evaluate the cost and efficacy of the noninvasive DNA sampling technique compared with traditional methods. To make this comparison, the park has received funding to draw blood from and radio-collar several mountain lions in 2003 and 2004 identified through the noninvasive techniques. ■

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Global environmental effects on the mountain ecosystem at Glacier National Park

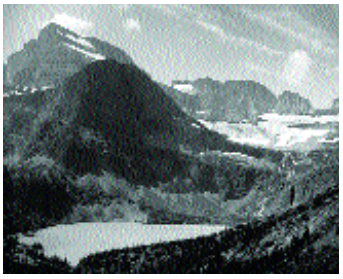
by Daniel B. Fagre

"Almost all mountain glaciers are receding as global temperatures increase."

THE GLACIERS OF GLACIER NATIONAL PARK, Montana, are shrinking and may be gone within our lifetime. At the end of the Little Ice Age (ca. 1850), an estimated 150 glaciers occurred within current park boundaries. By 1968 only 37 were deemed viable or large enough to warrant being named on maps. Until recently, park promotional literature claimed "around 50" glaciers in existence. This tally included a number of smaller, unnamed glaciers. However, by 1993 the largest of park glaciers had shrunk to less than a third of the area they previously covered, and many of the smaller glaciers had disappeared or were no longer large enough to be considered glaciers. The area within park boundaries covered by ice and permanent snow was reduced from 38 square miles (99 square kilometers) to 10 square miles (26 square kilometers). Furthermore, several computer models estimated that all the park's glaciers would be gone between 2030 and 2050 at current warming rates in the northern Rocky Mountains.

The decline of glacial ice generally is linked to an increase in average summer temperature and a reduction in the winter snowpack that forms and maintains glaciers. Temperatures in the nearby city of Kalispell indicate an increase of approximately 1.4°F (0.8°C) during the past century, but climate records are less complete for high-elevation landscapes within Glacier National Park. However, a weighted average of summer temperatures from climate stations surrounding the park indicates a more dramatic rise of 2.9°F (1.6°C) for the park environment. Furthermore, the period of most rapid temperature rise roughly coincided with rapid glacier recession and increased tree establishment at tree line. The average annual maximum snowpack has significantly declined over the past 50 years; snowpacks melt about 13 days earlier in the spring than they did 50 years ago. Less snow would explain continued glacier melting, but the limited longer-term snow records (1922–present) suggest no overall decline in snowpacks, leaving temperature increases as the likely cause for most of the glacier disappearance.

Scientists with the U.S. Geological Survey (USGS) and their collaborators continue to monitor and study the park's glaciers. A comprehensive overview of glacier information was published in 2002 by Carl Key (USGS), Dan Fagre (USGS), and Richard Menicke (NPS). Recently, USGS scientists completed an effort using repeat photography (e.g., comparisons of historical and recent photographs) for 56 sites in the national park. Comparing photographs of 17 of the remaining glaciers reveals that glaciers continue to recede. Thirteen of the 17 glaciers are distinctly smaller when compared with photographs taken at various times in the 1900s. Based on a precision global positioning system survey of Grinnell Glacier, more than 35 acres (17 hectares) have been lost from a relatively small glacier since 1993. Finally, ground-penetrating radar surveys show that glacial ice has thinned by as much as 50% over the past two decades. Therefore, as Grinnell Glacier is both thinner and covers less area, it has less than 10% of the ice volume it had in 1887 when it was first described. All glaciers in the park for which there are recent measurements continue to lose ice volume. This corresponds well with the fate of glaciers elsewhere on Earth: almost all mountain glaciers are receding as global temperatures increase.



GLACIER NATIONAL PARK ARCHIVES, BY KISER

Glacier recession is evident in this comparison of Grinnell Glacier in 1910 (black and white image) and 1998 (color image). Repeat photography at Glacier National Park has shown a decrease in size among 13 of 17 park glaciers.

U.S. GEOLOGICAL SURVEY, BY KAREN HOLZER

The ecological significance of losing glaciers at Glacier National Park includes loss of stream base flow in late summer and higher water temperatures that influence the distribution and behavior of aquatic organisms. Glaciers are very popular features of the park, and a certain sparkle will be gone when the last glacier disappears. ■

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Soils inventory unearths new species at Great Smoky Mountains National Park

by Mike Jenkins and Pete Biggam

NPS PHOTO

Distinct vegetation communities of the southern Appalachian Mountains, heath balds are dominated by extremely high densities of evergreen shrubs. The shrubs produce a thick layer of highly acidic leaf litter, resulting in acidic surface soils that resist invasion by tree seedlings. The ongoing soils survey documented 21 new "species" of soils in Great Smoky Mountains National Park and spawned further studies of the heath bald soils.

STUDYING SOIL MAY SEEM AS DULL AS DIRT, BUT soil scientists are finding exciting new worlds in the earth underlying Great Smoky Mountains National Park. The Soil Resources Inventory is giving park staff and researchers valuable information on the role of soils in ecosystems. To date, approximately 65% of Great Smoky Mountains National Park has been mapped, and soil scientists have encountered 21 new "species" of soils not previously recognized. Most of them exist at elevations above 4,600 feet where climate and geologic materials interact in unique ways to form new soils. The National Park Service Inventory and Monitoring Program is working cooperatively with soil scientists from the USDA–Natural Resources Conservation Service to obtain detailed information regarding the physical, chemical, and biological properties of soils in the park. Once completed, the inventory will provide Great Smoky Mountains National Park with a powerful tool for ongoing management and research efforts.

One of the greatest limitations to the management of natural resources across a large area is poor understanding of species distributions and their relationship to the underlying physical environment. Physical and chemical properties of soils are known to be critical to the distribution of forest types and vascular plants, but these properties are also important on a smaller scale in determining the distribution of the vast number of species that comprise the flora and fauna of the park's soils. An All Taxa Biodiversity Inventory (ATBI) is being conducted to identify and determine distributions of all species of life in the park. Soil and leaf litter samples have revealed many species not only previously unknown in the park, but new to science as well. To date, 37 new species of springtails (primitive insects), 14 species of slime molds, 4 species of earthworms, and 3 species of land snails have been identified. Information from the soils inventory will allow scientists to understand the habitat needs of species identified by the ATBI and to predict their distribution and abundance throughout the park.

Although still in progress, the soils inventory has already revealed new areas for scientific study. For example, the unusual properties of the organic soils formed under heath balds have spawned a cooperative study with Western Carolina University to determine the age and paleoecology of these unique areas. Soil samples collected at various depths throughout the soil profile will be analyzed to determine the age of soil deposits and their rate of accumulation. This information may help solve the long-standing puzzle of how and when these distinctive vegetation communities were formed.

In addition to the soils inventory, efforts are being made to map the geology and vegetation communities of the park. These three layers of information will allow scientists to examine biological and physical relationships across the park at a level of detail never before possible, so that park managers may be better able to predict potential impacts of environmental threats. For example, the park receives some of the highest deposition rates of acidic sulfur and nitrogen in North America. Efforts are under way to model deposition levels across the park. Once this model is completed, resource managers will be able to understand which soil types are most vulnerable to acidification and which vegetation types and biological communities may be impacted. ■

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UNIVERSITY OF TENNESSEE, DR. ERNIE BERNARD

Primitive insects of the order Collembola, springtails exist in the tens of thousands per square meter of Great Smokies forest soil and leaf litter. The dark-colored specimen *(Pseudachorutes simplex)* is a common soil-dweller in the park; the pale specimen (genus *Neanura*) may be new to science.

Sound signatures may provide clues to the health of park ecosystems

by Bill Schmidt

THE NATIONAL PARK SERVICE RECENTLY completed the first round of a pioneering bioacoustic sampling of environmental sounds in selected locations in Sequoia and Kings Canyon National Parks, California. The work was performed by a team directed by Dr. Bernie Krause of Wild Sanctuary, Inc., in cooperation with Dr. Stuart Gage of the Computational Ecology and Visualization Laboratory at Michigan State University. The NPS Associate Director, Natural Resource Stewardship and Science, sponsored this study with funding from the Natural Resource Preservation Program.

Dr. Bernie Krause records the "biophony," or the combined sounds made by organisms in a given habitat, on location in Sequoia National Park, California. Bioacoustic recording adds another dimension to ecosystem modeling and allows for comparisons of data among seasons, over time, and with other ecosystems.

The underlying thesis of this project is that interpreting an area's *biophony*—the combined sound that living organisms produce in a given habitat—is a key to understanding the health of that particular biome or ecological community. In contrast to studying the vocalization of organisms in an abstract, individualized manner as has been done historically, this study focused on recording audio samples in the context of the totality of creature sounds in a given setting. The expression of biophony is theorized to depend on location, season, weather conditions, time of day, whether the biome is wet or dry, whether the habitat is primary or secondary growth, whether it is clear-cut or unchanged, and many other factors. If the thesis that each biophony is unique and tied to the health of a particular biome is borne out, the biophonic signature of an area can provide the National Park Service with a clear record of individual place and an indicator of its fitness and age just as a thumbprint identifies individual humans.

The study sought to:

1. Digitally record audio samples from four different habitats in the two parks from October 2001 to July 2002;
2. Process bioacoustic dynamics and characteristics of each habitat;
3. Begin creating an index of acoustic dynamics within each habitat to correlate with traditional biodiversity indexes;
4. Assess habitat degradation and regeneration; and
5. Begin examining the relationship of bioacoustic dynamics to introduced noise, such as from human sources.

Four teams made observations and collected audio samples. Personnel monitored per of the four sites four times per day over a period of three to five days, during fall, winter, spring, and summer, to start characterizing the natural acoustic dynamics of each site. Daily signatures of approximately 60 minutes of acoustic activity were recorded at dawn and dusk, which tend to be the most acoustically active periods, at midday, and two to three hours after sunset (representing nighttime). Park natural resource staff helped select the sites; the investigators selected seasons relative to typical weather patterns at approximate seasonal midpoints.

The results were very encouraging. The teams worked out many of the expected problems with the sampling protocols and equipment. They obtained a rich collection of biophonic information and have been working to establish preliminary correlations with traditional biodiversity indexes. In the words of Dave Graber, Senior Science Advisor for the parks, "recording a soundscape … in Sequoia represents a valuable component of a park's natural resources inventory, much like producing a vegetation map or a list of animal species.… Should concordance among various acoustic elements in a soundscape prove to be a widespread phenomenon, it … holds promise for a window into a whole new aspect of ecosystems that was heretofore undetected."

The results of the field test pointed out several areas for additional work. One is the need for analytical techniques, such as those from landscape ecology, that will allow quantification and more refined statistical analysis of the data. Even relatively short recording sessions such as these generate a tremendous amount of data that must be plotted and sorted by hand. Another need is for additional recording at these and other parks with different physical characteristics to provide multiyear data over a broad range of conditions. ■

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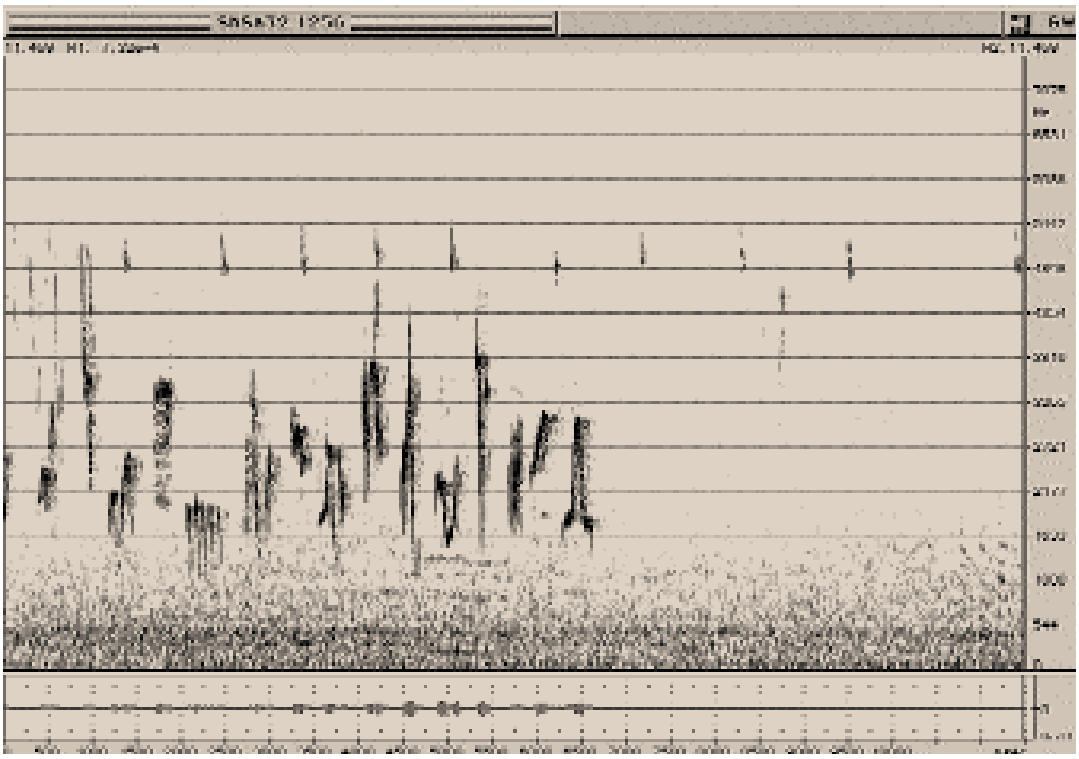
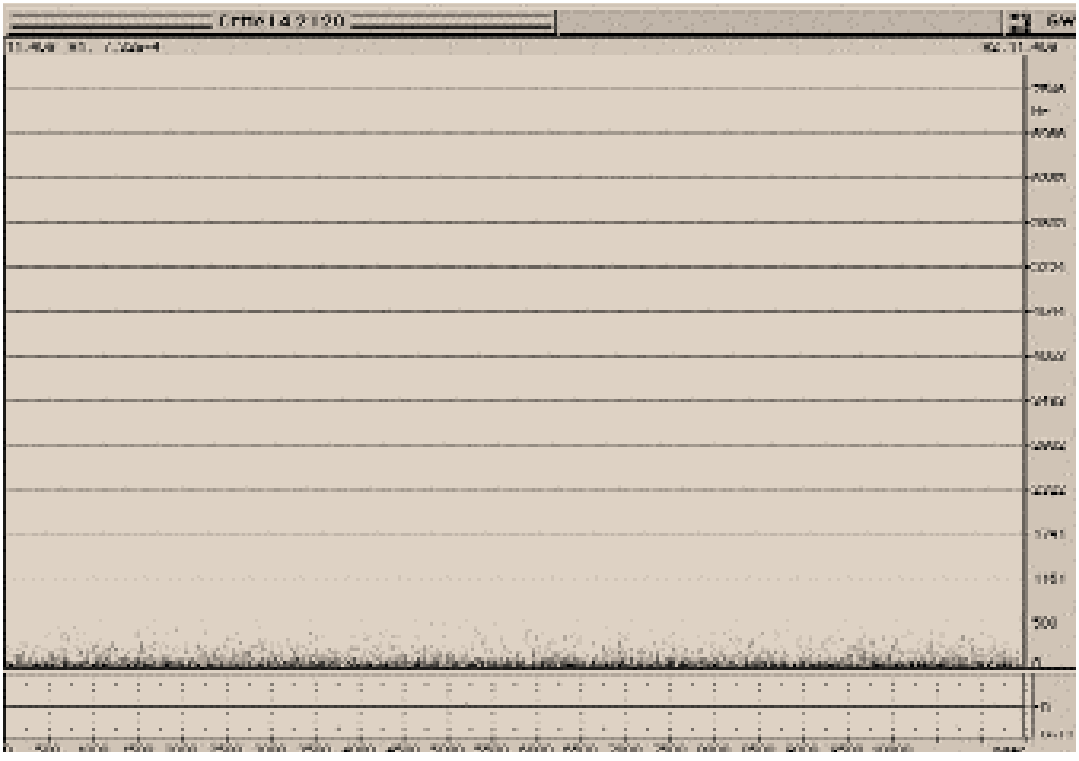
"This study focused on recording audio samples in the context of the totality of creature sounds in a given setting."





Spectrograms contrasting rich (above) and barren (below) biomes, Sequoia and Kings Canyon National Parks, California.

Horseshoe crab monitoring at Cape Cod National Seashore

by John Wullschleger and M. J. James-Pirri

NPS PHOTOS BY ABIGAIL MILLER

Enjoying a field-day retreat, NPS administrators from the Northeast Region lend their energies to the horseshoe crab spawning survey at Cape Cod National Seashore. Guided by NPS, USGS, and University of Rhode Island scientists, the managers measured and tagged crabs, which will allow researchers to estimate population size and assess migration. Left to right: Marie Rust (Northeast Regional Director), Johnnie Smith (Assistant to the Regional Director), Connie Rudd (Assistant Superintendent, Shenandoah National Park), Charles Roman (formerly with USGS, now with the North Atlantic Coast CESU), Beth Johnson (Regional Inventory and Monitoring Coordinator), Bob McIntosh (Associate Regional Director, Resource Stewardship, Planning, and Research), and Sandy Walter (Deputy Regional Director).

THE ATLANTIC HORSESHOE CRAB *(Limulus polyphemus)*, a species more closely related to spiders than to true crabs, inhabits coastal waters from Maine to the Yucatán peninsula. Although horseshoe crabs are not standard fare at seafood restaurants, they are economically and ecologically important. Horseshoe crabs are harvested for bait in conch and eel fisheries and to obtain limulus amebocyte lysate, a substance used by the biomedical industry. In addition to their intrinsic value, horseshoe crabs are an important link in the food chain. Adults are eaten by juvenile loggerhead turtles, a species that is federally listed as threatened, and the crabs' eggs, which are deposited on sandy beaches during high tides, are a preferred food item for many invertebrates, fish, and migratory birds. Horseshoe crab populations along the Atlantic Coast of the United States have recently been in decline. While the reasons for the coastwide decline are not known, human harvest is believed to be a contributing factor.

In 2000 concern over declining numbers led National Park Service managers to close Cape Cod National Seashore to the harvest of horseshoe crabs. This closure was initially opposed by the State of Massachusetts, which contended that the National Park Service usurped state authority to manage the harvest of fish and shellfish. It was subsequently determined that the closure was within NPS authority because horseshoe crabs are not classified by the state as either fish or shellfish. The national seashore currently remains closed to the harvest of horseshoe crabs; however, the issue underscores the need for better information about crab populations.

Park managers took the first step toward acquiring the information needed to manage and conserve horseshoe crabs by contracting with the University of Rhode Island to conduct spawning surveys in 2000 and 2001. The work was partially funded by the NPS Biological Resources Management Division and conducted in cooperation with the Massachusetts Audubon Society and the U.S. Fish and Wildlife Service. Surveys were undertaken on beaches and in other habitats during high tides from May through July. Researchers collected data to estimate spawning densities, sex ratios, and egg densities. Spawning crabs were measured and classified by age group based on the appearance of their hard outer covering, known as the carapace (carapaces of older crabs show greater wear and higher numbers of encrusting organisms). Crabs were also marked with plastic tags that allowed researchers to estimate population size and assess migration.

The final report, "Population Demographics and Spawning Densities of the Horseshoe Crab, *Limulus polyphemus*, within Cape Cod National Seashore, Cape Cod Bay and Monomoy National Wildlife Refuge, Massachusetts," notes that spawning densities were low at most sites. The highest spawning densities were observed in Monomoy National Wildlife Refuge, followed by Pleasant Bay in Cape Cod National Seashore. Size and age structure varied among locations, with the largest crabs of both sexes found at the wildlife refuge, followed by Pleasant Bay. Overall egg and larval densities were also low and were not correlated with spawning density. Recapture data for tagged crabs indicated that a few individuals traveled long distances, and the close proximity of most recaptured crabs to their original location suggests that spawning populations are generally discrete.

Although the demographic and density data cannot currently be tied to particular causes, this information provides a basis for identifying future trends in crab populations in Cape Cod National Seashore and the surrounding area. Better understanding of population dynamics and spawning densities of the Atlantic horseshoe crab will allow the National Park Service to make management decisions that protect the species, ensuring its continued contribution to the region's ecosystem and economy. ■

"Better understanding of population dynamics and spawning densities of the Atlantic horseshoe crab will allow the National Park Service to make management decisions that protect the species."

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CESUs in the Intermountain Region: Integrating natural and cultural resource research, technical assistance, and education

by Kathy Tonnessen, Pat O'Brien, and Ron Hiebert

"The CESUs of the NPS Intermountain Region … are integrating natural and cultural assistance to parks."

THE COOPERATIVE ECOSYSTEM STUDIES UNITS (CESUs) of the NPS Intermountain Region began an experiment in 2002 to expand their scope: they are integrating natural and cultural assistance to parks through the various CESU partners. The CESU network is a biogeographic-based partnership of universities, nongovernmental organizations, and federal agencies that provide federal resource managers with high-quality scientific research, technical assistance, and education. This network is engaged in studies of natural and cultural resources and social science.

A cultural resource specialist, Pat O'Brien, moved from the regional office to a position at the Desert Southwest CESU at the University of Arizona, Tucson. The other two CESUs in the region are in the midst of advertising for cultural resource specialists to be duty-stationed at the University of Montana, Missoula, and Northern Arizona University, Flagstaff. These three "cultural resource brokers" will provide the interface between natural and cultural resources and assist parks in finding partners to help with research, technical assistance, and education.

Examples of projects that combine natural and cultural resource management include archeological and paleontological surveys that serve to protect cultural resources while increasing our understanding of natural resource use through time. At Bent's Old Fort, Colorado, researchers from the University of Montana and Colorado State University are pursuing hydrologic studies to determine the cause of basement flooding of the fort. In recent years the water table throughout the Arkansas River Valley has risen because of changes in irrigation and river hydrology. A recently created, 55-acre wetland surrounds 50% of the fort, and groundwater from that wetland is seeping through the fort's foundation. Researchers have installed groundwater wells that are monitored regularly by park staff to collect seasonal data and detect changes in the water table. This technical assistance provided by the Rocky Mountains CESU is allowing park managers to understand the cause of the flooding and to plan a dewatering project to protect the structures in the park.

NORTHERN ARIZONA UNIVERSITY, PATTY WEST

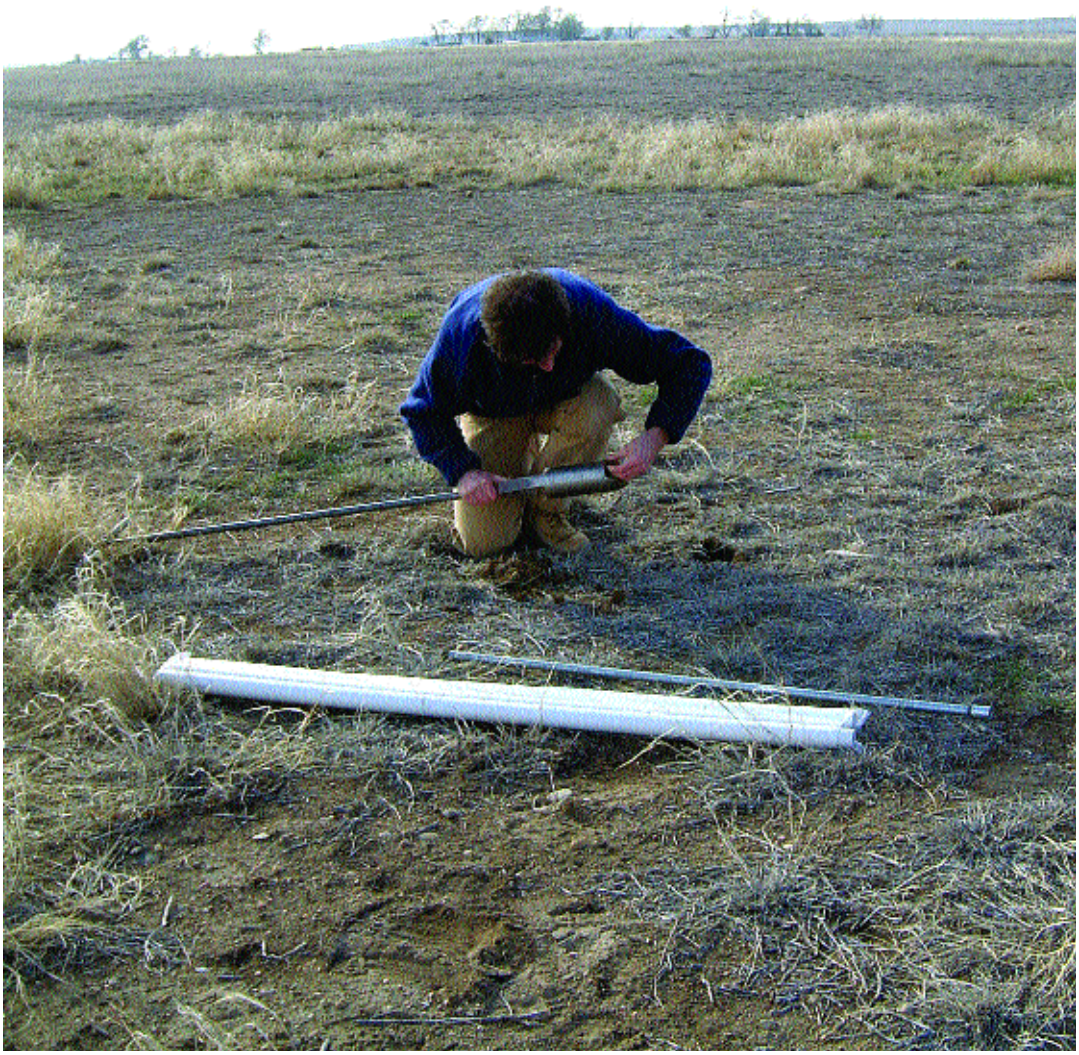
At Saguaro National Park, Arizona, researchers associated with the Desert Southwest CESU devised a plan for a study of the annual saguaro fruit harvest by the Tohono O'odham (Papago) tribe in the Tucson area. For centuries the Tohono O'odham have used the fruit of the saguaro cactus as a food source, and the harvest and processing of the fruits have become a central cultural focus of the tribe. An ethnographic inspection of this annual event will look at the native plant, its range of growth and various natural properties, and the role it plays in native mythology and culture.

At Navajo National Monument, Arizona, a project funded through the Colorado Plateau CESU involves Northern Arizona University,

NORTHERN ARIZONA UNIVERSITY, PATTY WEST

The oral tradition of passing on ethnobotanical information has decreased for many Navajo as a result of changing lifestyles. A CESU-sponsored investigation of ethnobotany at Navajo National Monument is documenting this knowledge before it is lost, including that retold by Navajo elder Keal Clitso (right) in the monument's Betatakin Canyon (top). The information will be used in park and Navajo Reservation resource management, interpretation, and environmental education.

A researcher prepares to install equipment to record seasonal changes in the water table at Bent's Old Fort, Colorado. The hydrologic study, coordinated by the Rocky Mountains CESU, will help diagnose the cause of flooding in the basement of the reconstructed historical fort and suggest remedies.



NPS PHOTO BY FRAN PANNEBAKER

Navajo Nation Historic Preservation, and the National Park Service in an investigation of Navajo knowledge and use of plants. The Southern Colorado Plateau Inventory and Monitoring Network is surveying existing vegetation in the monument. This collaborative effort will develop integrated ethnobotany documentation, interpretation, and community school-based environmental education. The work will result in culturally appropriate resource management recommendations for use by Navajo National Monument and the Navajo Nation Division of Resource Management.

With the addition of cultural resource specialists at the three CESU host universities of the Intermountain Region, more applications of research are possible that combine the natural, cultural, and social sciences to meet park management needs. The wide array of expertise among CESU researchers at federal agencies and universities allows for this integration and flexibility. ■

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Park Flight: Connecting people and protected areas through technical exchange

by Carol Beidleman

"The international cooperation sparked by such programs is critical for the success of species that spend part of the year in one country and part of the year in another."

THE SCENE CAPTURED THE ESSENCE OF THE PARK Flight Migratory Bird Program. In the tropical rainforest of Pico Bonito National Park in Honduras, three biologists from the United States and three interns from Mesoamerica were reunited in November 2002 for a workshop to improve knowledge and coordination of migratory bird monitoring programs across the hemisphere. These internships, coordinated through the NPS Office of International Affairs Volunteers-in-Parks program, provide an opportunity for technical and cultural exchange and enhance opportunities for collaboration on migratory bird conservation.

The international cooperation sparked by such programs is critical for the success of species that spend part of the year in one country and part of the year in another. Innovative programs like Park Flight are important for keeping resource managers abreast of issues that might affect migratory species at either end of their journey. Initiated in 1998 and enhanced by funding from the Natural Resource Challenge, Park Flight is a partnership among the National Park Service, the National Park Foundation, American Airlines, the National Fish and Wildlife Foundation, the U.S. Agency for International Development, and the University of Arizona CESU (see page 34).

NPS PHOTO

Park Flight international interns reunite with biologists from the United States at a workshop in Honduras to coordinate migratory bird monitoring programs across the hemisphere. Pictured from left to right are Alexis Cerezo (Guatemala), Rachel Mazur (Sequoia–Kings Canyon National Park), Belkys Jimenez (Panama), David Mizrahi (New Jersey Audubon Society), Edgar Castañeda (Nicaragua), and Bob Kuntz (North Cascades National Park); missing is Phil Correll (New Jersey Coastal Heritage Trail Route). Each Mesoamerican country's Park Flight grantees received new binoculars at the workshop, donated by Optics for the Tropics. Park Flight is dedicated to conservation of migratory bird species in U.S. and Mesoamerican national parks and protected areas.

At the Honduras workshop, several of the interns gave an overview of their national park experiences. They are all biologists who manage bird conservation programs in their home countries. Alexis Cerezo from Guatemala spent 10 weeks at Sequoia and Kings Canyon National Parks, where he and Miguel Ramirez banded birds at Monitoring Avian Productivity and Survivorship stations, conducted backcountry monitoring, and gave interpretive programs. Alexis said it was "the most beautiful place he had ever seen in his life" and expressed appreciation for the trust accorded to him by NPS Wildlife Biologist Rachel Mazur.

Edgar Castañeda from Nicaragua, one of three interns hosted by North Cascades National Park, assisted with a Cornell Citizen Science bird monitoring project, helped plan a migratory bird exhibit, and gave a presentation to Spanish-speaking families from Skagit County. He said Bob Kuntz and the other staff at North Cascades "treated him like family." Belkys Jimenez from Panama interned with the New Jersey Audubon Society and New Jersey Coastal Heritage Trail Route, where she assisted with interpretive walks, songbird banding, and hawk counting. She left New Jersey eager to start a hawk-counting station in Panama. Each of these activities gave the interns an opportunity to increase their understanding of migratory bird management in the United States and improve their English skills. Both the interns and host parks found the exchange experience professionally and culturally rewarding.

Another important component of the Park Flight Program is providing technical assistance to Mesoamerican bird conservation projects, with NPS expertise matched to needs identified by Mesoamerican partners. In 2002 Park Flight gave technical assistance in five Mesoamerican countries, coordinated through the NPS Office of International Affairs. Eric Finkelstein of Amistad National Recreation Area, Texas, provided interpretive expertise for the development of bird-watching trails in El Imposible and Montecristo National Parks in El Salvador. At the same time, Steve Burns, a landscape architect with the NPS Long Distance Trails Office in Santa Fe, New Mexico, designed a bird-watching route between these two national parks to promote avitourism. Another NPS landscape architect, Kevin Percival, developed a site plan for a visitor reception area at Mombacho Volcano Natural Area, Nicaragua.

Environmental educators Roy Simpson, from Tumacacori National Historical Park, and Sarah Koenen, from George Washington Memorial Parkway, provided training and recommendations for the Panama and Mexico Park Flight projects, respectively. Edgar Castañeda received technical assistance in Nicaragua the previous year. The Park Flight Program made it possible for him to participate in activities at both ends of the migration route, completing the migratory bird management and monitoring link across the hemisphere. ■

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NPS PHOTO AND GRAPH

Monitoring glacier change in the North Cascades

by Rob Burrows and Jon Riedel

Glaciers in North Cascades National Park, Washington, have retreated rapidly for most of the past 150 years, with a 44% reduction in ice cover. However, steady retreat has slowed periodically because of 5- to 10-year-long cold and wet periods, including 1997 to the present. More than 300 glaciers in North Cascades National Park and its contiguous units, Lake Chelan National Recreation Area and Ross Lake National Recreation Area, are vital components of Pacific Northwest aquatic and terrestrial ecosystems and hydrologic systems. These glaciers influence stream flows, flooding, soil development, vegetation distribution, water quality, and water delivery to hydroelectric projects, and are important indicators of climate change.

The National Park Service has monitored mass balance on three glaciers in North Cascades National Park since 1993 (four since 1995), tracking total winter snow accumulation and summer melt. In 2002, above-average winter snowfall led to minor growth of three of the four glaciers. Glaciers provided up to 40% total summer stream runoff and meltwater during extremely dry conditions in late summer and throughout the fall, helping maintain flows for threatened salmon species. Annual variations in balance match other glacier studies and climate records in the Pacific Northwest and are correlated to climate indexes such as El Niño, or Southern Oscillation, and the Pacific Decadal Oscillation.

Partners providing data, funding, and volunteers include the Earthwatch Institute, Seattle City Light, the USDA Natural Resource Conservation Service, and the U.S. Geological Survey. Natural Resource Challenge funding is integral to the stability of this program. In 2002 the Challenge also funded initiation of a glacier monitoring program at Mount Rainier National Park, with another to begin in one to two years at Olympic National Park. ■

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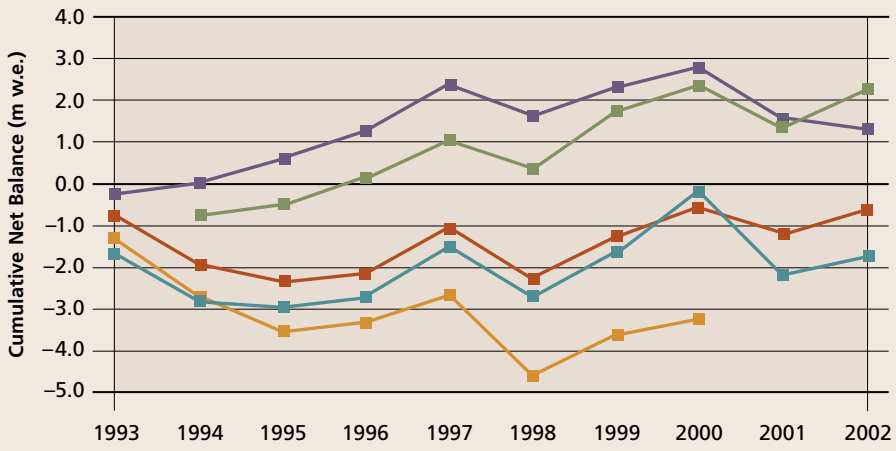
Legend

- Noisy
- Silver
- North Kiawatti
- Sandalee
- South Cascade

"m w.e." stands for meters of meltwater equivalent

CUMULATIVE GLACIER CHANGE IN THE NORTH CASCADES



AWARD-WINNER PROFILE

Tonnessen finds success as CESU coordinator

COURTESY OF KATHY TONNESSEN

Kathy Tonnessen

Dr. Kathy Tonnessen describes herself as tenacious, smart, organized, and persistent. And she's right on. All these attributes have contributed to her success as research coordinator of the Rocky Mountains Cooperative Ecosystem Studies Unit (CESU). For her accomplishments in this new role Kathy won the Director's Award for Natural Resource Research in 2002.

Two years ago Kathy was selected by the National Park Service as one of its first CESU coordinators in the country. After relocating to Missoula, Montana, her task was to assemble a team of researchers and technical specialists through the University of Montana with whom the National Park Service could collaborate on park research questions. Then she had to find creative ways to fund the variety of research projects from the 15 national parks served by this CESU. Kathy says it was not an easy task: "It was just starting from scratch. There were no people, no organization; it was a lot of work."

The role Kathy plays now has been called "marriage broker"; she brings together parks that need research with scientists who need field time. The resulting partnership of the Rocky Mountains CESU is functioning well and has addressed many national issues, such as wildlife and fishery diseases, management of ungulate populations, air quality, exotic plant management, and threatened and endangered species.

Kathy's work with the Rocky Mountains CESU has set a high standard after which other CESUs are being modeled. ■

Elk effects and management considerations studied at Rocky Mountain

by Therese Johnson

Elk management in Rocky Mountain National Park (Colorado) is a complex issue that has concerned park managers and the public for many decades. Elk migrate outside the park seasonally, necessitating a regional management approach among various agencies responsible for land and wildlife management, each with its own objectives and management constraints. The issue is complicated by interactions among multiple natural resources and the residual impacts of historical land use and wildlife management practices. It is controversial because of value conflicts among stakeholders regarding desirable elk numbers and the acceptability of the management actions required for ecosystem restoration.

In 2002 the National Park Service and the U.S. Geological Survey completed a large-scale research initiative designed to assess the role of elk and other factors (e.g., hydrology, climate, forage competition, predation) in influencing ecosystem conditions. Numerous investigators conducted 13 interdisciplinary yet integrated studies using both field study and computer modeling approaches.

Results suggest the current elk population is larger and more concentrated than would be expected under natural conditions. The field studies show that willows (*Salix* spp.) have declined on the core elk winter range because of a variety of factors, including intense foraging by elk and changes in water flow and levels related to large declines in beaver. Model results predict that further shifts from biologically diverse willow and aspen communities to less diverse grasslands will occur if elk browsing is not reduced. The model also predicts that restoring natural conditions will require a combination of long-term, intensive management actions to redistribute and reduce elk numbers, restrict elk access to willow and aspen communities, and restore hydrologic conditions. The research results provide the strong scientific basis that will be critical to making and successfully implementing management decisions in the future. Rocky Mountain is developing an Elk and Vegetation Management Plan/Environmental Impact Statement in cooperation with other agencies responsible for land and wildlife management in the region. ■

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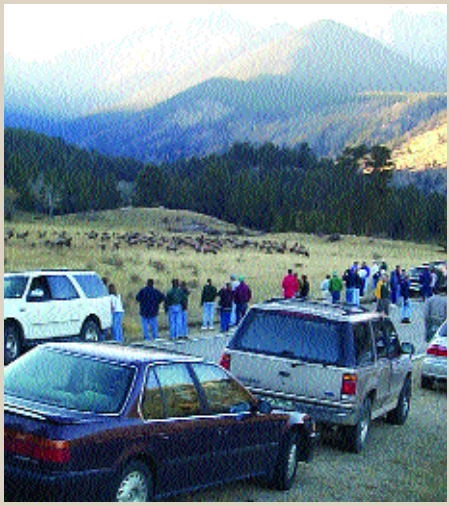

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PARTNERSHIP PROFILE

NPS PHOTO

Park Flight coordinator Carol Beidleman (left) with Mexican colleagues: monitoring expert and professor Fernando Villaseñor Gómez and environmental educator Aída Hernández Fernández.

A model for international conservation of birds

by Gary Johnston

The coordination of the Park Flight Migratory Bird Program (see page 31) is made possible through the Desert Southwest CESU, hosted by the University of Arizona. Through the CESU, Research Specialist Carol Beidleman devotes her considerable knowledge, experience, and capacity to the program, the National Park Service, and the other program partners. As a former NPS employee, she understands and appreciates the NPS mission and operations. Additional experience with The Nature Conservancy and involvement with Partners in Flight honed her program coordination skills and ability to develop effective partnerships for international migratory bird conservation. The CESU model is effective in giving her the flexibility and autonomy necessary to coordinate the activities of the many program partners. Carol and her program are examples of successful international conservation efforts. ■

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NPS PHOTO

Trace fossils such as these feeding structures reveal life habits and activities of extinct animals and plants and give clues to ancient environments. Worm cast fossils record the size and activities of animals whose soft body parts would not otherwise be preserved.

Survey adds to understanding of ancient life-forms

by Elaine Hale

Under Wyoming's summer sun in August 2002, an interdisciplinary, interagency team conducted a paleontological survey of the middle Cambrian exposures on Trilobite Point in Yellowstone National Park that added to the scientific understanding of ancient life-forms and their environments. The research effort also built on the National Park Service's growing commitment to partnerships; paleontologists from Fossil Butte National Monument (Wyoming), the Smithsonian Institution's National Museum of Natural History, the Yellowstone Gateway Museum, and Russia joined park professionals on the research team. The Yellowstone Park Foundation provided project funding.

The survey team identified numerous fossil-bearing locations that yielded a diverse collection of species, including three distinct genera of trilobites, early arthropods. Previous research on trilobites found on Yellowstone National Park's Mount Holmes contributed to the development of speciation theories for these organisms. Brachiopods, hyoliths, fossil fragments of sponge spines, and crinoids were also collected. Trace fossils of worm burrows and tracks provided evidence of animal behavior that gives clues to ancient environments. The inventory clearly demonstrates that the sedimentary rocks of the Cambrian period in Yellowstone possess fossil information concerning the "Cambrian Explosion," the relatively sudden appearance of complex multicellular organisms. The baseline information gathered by the survey gives researchers, resource managers, and resource protection rangers a better understanding of fossil resources and the threats facing them. A full report of the project will be available in May 2003; the collected specimens will be available for research and display at the new Yellowstone Heritage and Research Center, to be completed by summer 2004. ■

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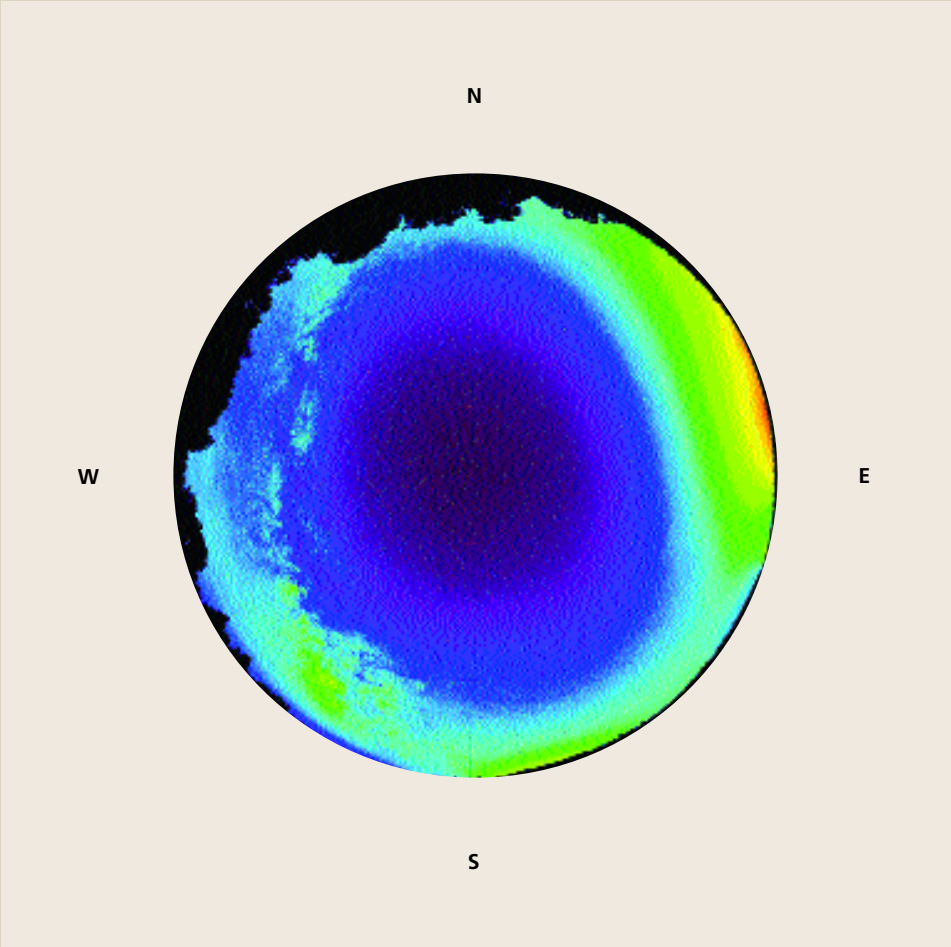
Monitoring and preserving dark skies

by Chad Moore and Dan Duriscoe

Experiencing a night sky filled with a blanket of stars becomes increasingly difficult at national parks. The growing populations in the western United States and the spread of development into rural areas have made light pollution a significant management issue for the National Park Service. In 2002 the NPS Night Sky Team, composed of park scientists and managers, continued efforts to monitor and preserve dark night skies, focusing on strategies to address impediments to protection. Obstacles within the Park Service include a lack of awareness of light pollution as a threat to wilderness values and cultural heritage, an absence of baseline information about this resource, and inefficient facility lighting.

The team tackled the awareness problem with an outreach effort to park managers and the public. Research presented at a conference cohosted by the Night Sky Team demonstrates that artificial night lighting not only diminishes the visitor experience but also has ecological consequences, influencing the behavior, biology, and survival of animals. A National Public Radio program examined endangered night skies in national parks, and a special issue of the *George Wright Forum*, edited by Joe Sovick, chief of recreation and partnerships for the Intermountain Region, received widespread attention.

Collecting baseline inventories for several parks represented a major effort in 2002. Astronomers at the U.S. Naval Observatory and the Lowell Observatory (both in Flagstaff) provided invaluable assistance with the development of research methods. More than 40 data sets now cover many southwestern parks. Preliminary analysis of the data shows that near-pristine skies can be found in those areas farthest from major cities and describes impairment caused by light pollution sources. For example, data from Walnut Canyon National Monument, 8 miles from Flagstaff, Arizona, indicate that although light from the city obviously causes light pollution, the night sky is far darker than would be expected (see image). The community has adopted lighting ordinances and retrofitted many outdoor lights. Scientifically sound information is vital for tracking mitigation efforts and encouraging public support.



NPS PHOTO

This panorama shows light levels in the night sky over Walnut Canyon National Monument, Arizona. Although Flagstaff, population 75,000, is evident to the west, the sky is much darker than would normally be expected given the town's proximity and population. A coalition of observatories, government agencies, private companies, and the public has enacted lighting ordinances and retrofitted many outdoor fixtures to improve lighting efficiency. Scientific records like this are useful for tracking mitigation efforts and encouraging public support to preserve dark night skies.

In 2003 the Night Sky Team will expand efforts nationwide and seed individual inventory and monitoring networks with "satellite" night sky teams. ■

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